"Solar Eclipse of May 28, 1900. Preliminary Report of the Expedition to the South Limit of Totality to obtain Photographs of the Flash Spectrum in High Solar Latitudes." By J. EVERSHED. Read at Joint Meeting of the Royal and Royal Astronomical Societies, June 28, 1900. MS. received July 16, 1900.

This expedition was one of those organised by the Joint Permanent Eclipse Committee of the Royal Society and the Royal Astronomical Society, funds being provided from a grant made by the Government Grant Committee.

The following were the principal objects which I had in view in arranging the expedition:—

To obtain a long series of photographs of the chromosphere and flash spectrum, including regions of the sun's surface in mid-latitudes, and near one of the poles.

The photographs to be obtained with a long focus prismatic camera on a large scale, in order to be able to discriminate clearly between high levels and low levels in the chromosphere.

The photographs to include as much as possible of the ultra-violet region of the spectrum, for the purpose of verifying the results obtained with a smaller instrument in 1898, and to give more accurate values of the wave-lengths determined from those results.

This report may be conveniently divided into the following four sections, viz.:—

1. Selection of observing station.
2. Instruments, methods of mounting, and general arrangement of camp.
3. Narrative of expedition, and observations made on the day of the eclipse.
4. Results.

(1) *Selection of Observing Station.*

A consideration of the conditions under which the lowest layers of the chromosphere are presented during a total solar eclipse showed that a very great advantage would be gained by selecting a station situated near the limit of the zone of total eclipse, where the two internal contacts would be separated by a small angle on the sun's limb.

At such a station the motion of the moon relative to the sun is in a direction approximating to parallelism with a tangent to the sun's limb at the points of internal contact, the result being that the excessively shallow layer giving rise to the so-called "flash spectrum" is

occulted by the moon comparatively slowly. Much more time is therefore available for taking a series of photographs than is the case at stations near the central line of the eclipse, where the moon's motion is at right angles to the layer, and opportunities for obtaining photographs of the very lowest strata are reduced to a fraction of a second only at each internal contact.

I decided therefore to choose some point situated well within the zone of total eclipse, but so far from the central line that the two internal contacts would be separated by an angle of about 39° on the sun's limb. This would give a duration of totality equal to one-third that at the nearest point on the central line; and the time available for photographing the flash spectrum would not be less than 30 seconds. At mid-eclipse the moon's limb would overlap the photosphere about 1″, so that even at that time the flash spectrum layer would not be entirely hidden.

Under these circumstances, also, one of the contacts would take place at, or very near to, one of the poles of the sun, the other being in latitude 51°. A succession of photographs taken during totality would therefore give a series of images of the flash spectrum ranging from solar latitude 51° to the pole.

In selecting the most suitable station, dryness of climate was considered to be the most important factor for securing extension of the spectra in the ultra violet; I therefore selected Algeria in preference to Spain, although the altitude of the sun would be less in the former country.

The best position in Algeria for realising the greatest solar altitude was a point on the coast west of Algiers, and on the southern border of the eclipse track. This region was therefore decided upon at the outset, and in order to realise the favourable conditions mentioned above, two stations were selected provisionally beforehand, and for these Dr. Downing kindly computed for me the durations of totality according to the data used by the Nautical Almanac Office.

The first station, near to the village of Zeralda, was found by him to have a duration of 45 seconds, *i.e.*, more than one-half the central line duration. The other station, three miles further south, and near to Maelma, was computed to have a duration of 29·5 seconds with a possible error of ± 10 seconds.

As the required conditions would, apparently, be very nearly fulfilled at the latter station, I decided to place my camp either at that precise spot, or at some point situated on a line passing through it, and parallel to the direction of the shadow track in that region.

The actual station eventually chosen was 6·5 kilometres distant from the station near Maelma, in a direction bearing West 25° North. Here it was estimated that totality would last 30 seconds. Unfortunately, as the event proved, the value of the diameter of the moon adopted by

our Nautical Almanac Office is too large, and the limits of error given above were very misleading. Instead of a duration of 30 seconds, the eclipse at my station was never quite total.

(2) *Instruments, Methods of Mounting, and General Arrangement of Camp.*

It was my intention originally to take out a fine 18-inch silver-on-glass concave mirror made by the brothers Henri, which was given to me by the late Mr. Ranyard. This mirror, having a focal length of 117 inches, would have given images on a scale of 1·08 inch to the sun's diameter

Many experiments were made with this mirror to determine the amount of aberration produced on star images at considerable distances from the axis, and with various apertures. It was found that when the ratio of aperture to focal length did not exceed 1/15, good images were obtained 4° from the normal axis, the aberration being very slight.

As this would admit of a very wide range of spectrum being photographed with good definition throughout, I decided to adapt my large reflecting telescope for eclipse work. Owing, however, to the difficulty of obtaining a prism of large angle and not less than 6 inches aperture, I had, most unfortunately, to abandon this scheme and construct a much smaller apparatus.

Through the kindness of Dr. Rambaut I eventually obtained a fine 4-inch prism of light flint glass and 45 degrees angle. This prism, which was generously placed at my disposal by Sir Howard Grubb, proved most efficient for the work, although I was unable to utilise the full aperture.

Three spectrographs were finally made: a reflecting prismatic camera of 3 inches aperture and 74 inches focus, an ordinary prismatic camera of 2 inches aperture and 47 inches focus, and a quartz prismatic camera of 1 inch aperture and 24 inches focus. These were mounted together inside an observing hut, and were supplied with light from a 12-inch cœlostat.

The Reflecting Prismatic Camera.

This was an ordinary reflecting telescope with a mirror of 9 inches aperture and 74 inches focus. It was fitted with a strong wooden tube, adapted for carrying two large prisms near the upper end. The prisms used were the 4-inch 45-degree prism, lent me by Sir Howard Grubb, and a 3-inch 60-degree prism lent me by Dr. Common. These were mounted eccentrically within the tube, in such a manner that the incident light, after passing through the prisms, made an angle of about $1\frac{1}{2}°$ with the normal axis of the mirror. After reflection from the mirror the rays returned over the upper surface of the 60-degree prism, and came to focus about an inch outside the end of the tube.

The end of the tube was closed by a block of wood having an aperture 8 inches long by 3 inches wide, a little above the middle. Outside this a long slide was arranged, at right angles to the telescope, and bolted at the upper end to two stay rods attached to the telescope near the mirror.

A plate holder, 3 feet long by 10 inches wide, taking two plates $8\frac{1}{2}$ inches square and four plates $8\frac{1}{2}$ by $4\frac{1}{4}$ inches, was arranged to move along the slide by means of rackwork and a pinion wheel. One revolution of the pinion moved the plates 2·13 inches, whereby four images could be obtained on the square plates and two on each of the narrow ones; the sixteen images all being equal distances apart and symmetrically placed on the plates. The revolutions of the pinion wheel were controlled by a spring catch acting on the crank handle, and holding it firmly in position after each revolution.

The whole slide, carrying the plate holder, &c., was attached to the telescope in such a way that the distance of the plates from the mirror could be varied a small amount for focussing.

The tube of the instrument was firmly bolted down to the sloping side of a solid pier of stone and cement, built up within the observing hut near the north end. It was adjusted so that the plane of dispersion of the prisms was in a meridian passing through the cœlostat, and inclined to the prime meridian 68° (the hour angle of the sun at mid-eclipse). The dispersion was therefore in a north and south direction. The internal contacts were computed to occur near to the south point of the sun, and on either side of it. The centre of the flash spectrum arcs was therefore midway between the edges of the spectrum in the photographs obtained at mid-eclipse.

The 2-inch Prismatic Camera.

This instrument was the same which I employed successfully at the Indian eclipse in 1898, excepting that it was fitted with a specially corrected lens of 47 inches focus instead of the visual objective previously used. The images were therefore on a somewhat larger scale, and larger plates were used.

The sliding plate holder, constructed on the same lines as the larger instrument already described, was made to hold three plates, $6\frac{1}{2}$ by $4\frac{1}{4}$ inches, placed lengthwise in the holder; and the crank handle moving the slide was arranged to stop at each half revolution, moving the plates 1·12 inches between each exposure.

The two 60° prisms of this instrument are made of specially selected crown glass, and are exceptionally transparent for ultra-violet rays.

The total deviation of the two prisms being approximately equal to that of the reflecting spectrograph (about 80°) the tubes of the two in-

struments were arranged nearly parallel, the 2-inch spectrograph being screwed to the side of the reflector with its aperture alongside that of the latter. The camera end with the sliding plate holder was at the lower end.

The Quartz Prismatic Camera.

This was rigged up while in camp, as it was found that a small portion of the cœlostat mirror was available to supply light. It consists of two double quartz prisms of 60° and 40° angle respectively, each prism having $1\frac{1}{4}$-inch square faces; and a single quartz lens of 24 inches focus. It was screwed on the top of the 2-inch spectrograph, with its aperture just within the elliptical beam of light from the cœlostat.

My brother arranged a very convenient exposing shutter, which he was to open near mid-eclipse for a single exposure of 10 seconds.

Methods of Focussing.—All three spectrographs were approximately focussed by taking a series of photographs of the spectrum of Venus. Having determined the focus of the reflecting prismatic camera in this way within very narrow limits, I used this instrument as a collimator for the 2-inch spectrograph, removing the large prisms, and adjusting a slit in the position occupied by the plates when photographing Venus. The 2-inch instrument was attached to the wall of the hut, with its aperture inside the tube of the reflector, and directed towards the mirror. With the north door of the hut widely open, the slit was illumined by light from the sky, and a series of photographs was obtained of the Fraunhofer spectrum.

For some reason the focus was not so sharply defined, and the definition of the lines was not so good as in photographs I had obtained by the same method before leaving England.

A third method was therefore tried. After having adjusted the 2-inch spectrograph in its correct place, photographs were obtained of the sun itself on Sandell triple plates; the focus being determined by the images which were most sharply defined along the edges.

A final method, which was adopted for the two larger instruments, was to adjust the focus visually during the eclipse itself, using the Fraunhofer lines, which become sharply defined shortly before totality.

Programme of Exposures.—The two larger prismatic cameras were each to have sixteen exposures made simultaneously, by removing a plate of aluminium from the common aperture of the two instruments. The first, second, fifteenth, and sixteenth exposure were to be of about 1 second duration each, and the remaining exposures of 2 seconds duration, excepting the exposure nearest to mid-eclipse, which was to have 10 seconds.

The quartz prismatic camera was to be exposed near mid-eclipse also for 10 seconds

These relatively long exposures were designed to secure density in the ultra violet, at the risk of over-exposing in the region near G.

Having ascertained by rehearsing that the time required for exposing all the plates would be about 90 seconds, I arranged that the first exposure should be timed at 45 seconds before the computed time of mid-eclipse The succeeding exposures were to follow each other at the shortest intervals, turning the handles deliberately, and allowing ample time for shake to subside before each exposure.

I was to use my discretion to some extent in making the long exposure at mid-eclipse, but otherwise I intended to be guided solely by the chronometer.

The exposures were to be made by myself, standing at the north door of the hut and facing the large spectrograph. I used my left hand to work the exposing shutter, and my right to rack the plates forward in the slide.

My brother, sitting on his bed in the hut, was to move the plates of the 2-inch spectrograph, turning the handle half a revolution after each exposure. He was also to expose the quartz spectrograph at a signal from me.

The Cœlostat.

A 12-inch cœlostat was used to supply light to the three spectrographs in the hut. It was placed about 6 feet from the north-east corner of the hut, and was arranged to reflect the sun in a meridional plane; the angle between the incident and reflected beam being in this case a minimum, viz., declination of sun $\times$ 2. The reflected beam was in a direction W. 30° S., and was directed upward at an angle of $3\frac{1}{2}°$ with the horizontal.

The instrument was mounted on a steel plate fixed on the top of a masonry pier, and about 3 feet from the ground. The plate had a straight channel cut in it just wide enough to take the ends of two of the four levelling screws, the other two resting on the planed surface of the plate.

With the plate placed approximately level and the channel approximately north and south, the whole instrument could be shifted bodily north or south without disturbing the adjustments of the axis in altitude and azimuth. In this way the adjustment of the beam of light with respect to the apertures of the three spectrographs was very easily managed, and the cœlostat could be shifted about to suit the varying declination of the sun on occasions, previous to the eclipse, when it was desired to observe the spectrum and adjust the spectrographs.

The cœlostat was provided with slow motion independent of the driving gear, and this was controlled from inside the hut by means of a rod, 8 feet long, which my brother laboriously cut from a 3-inch plank.

The driving clock was bolted down to the north end of the cœlostat pier. It was driven by a weight suspended from a large tripod erected near.

The $3\frac{1}{4}$-inch Telescope.

In addition to the photographic instruments I had a $3\frac{1}{4}$-inch equatorial telescope, and a high dispersion solar spectroscope. The telescope was mounted on a packing case outside the hut, and was useful in a variety of ways. With the spectroscope attached it was used for the observation of solar prominences on the day of the eclipse, and on several other occasions.

The Observing Hut.

This was a rectangular wooden shed, the sides enclosing a space 14 by 9 feet and 6 feet high. The sloping roof was covered with boards up to about 1 foot from the centre beam. A large sheet of canvas was stretched above the boards, leaving an air space between: this allowed of the free circulation of air between the canvas and the wood, and was designed to prevent the interior from becoming unbearably hot during the day.

This arrangement, however, was anything but water-tight, as we found to our cost during a spell of bad weather. We subsequently procured a large rick cover, which was tied securely over the canvas and down to the ground on the weather side of the hut.

This hut was designed by my brother for the accommodation of the somewhat unwieldy reflecting spectrograph and two camp beds. The frame was constructed by him before leaving England.

The accompanying ground plan shows the general arrangement of the camp.

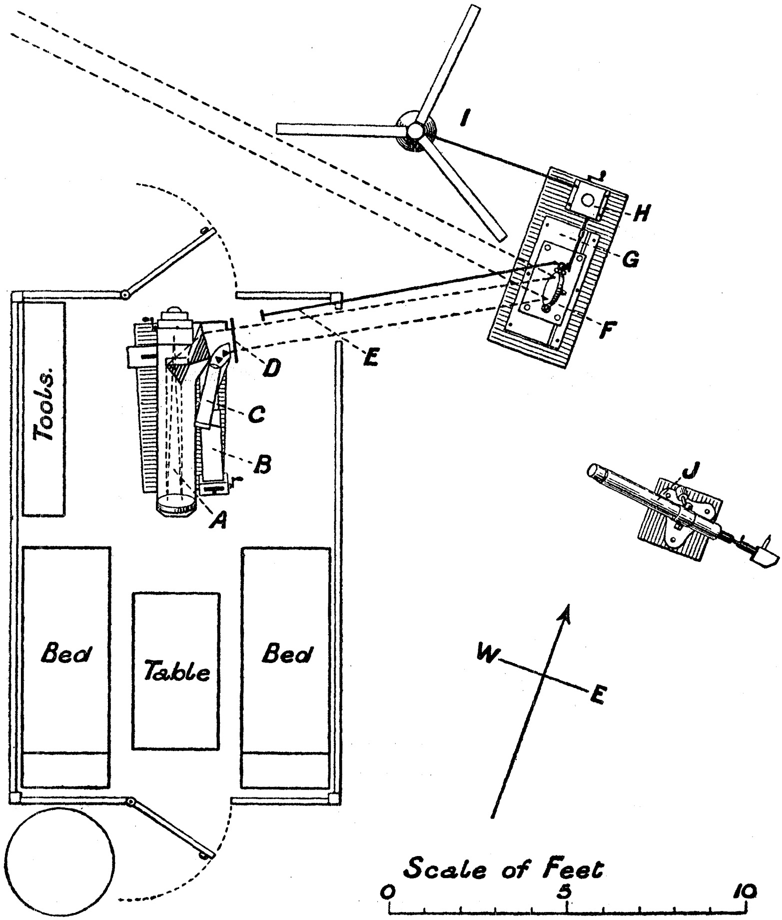
(3) *Narrative of Expedition and Observations made on the Day of the Eclipse.*

The expedition, consisting of my brother (Mr. Harry Evershed) and myself, left England on April 30th, and travelling *via* Paris and Marseilles arrived at Algiers on May 3rd.

At Algiers we received every attention and assistance from the British Consul-General, Mr. Hay Newton, to whom our acknowledgments are due. He procured for us a letter from the Préfecture to the Mayor of Maelma, ordering the latter to assist us in every possible way in selecting a site for our camp.

We also received assistance and advice from M. Trépied, of the Algiers Observatory, who very kindly called at our hotel and discussed with us our plan of operations.

PLAN OF OBSERVING STATION, MAZAFRAN CAMP.



A. Reflecting spectrograph.	F. Cœlostat.
B. 2-inch spectrograph.	G. Planed steel plate with channel.
C. Quartz spectrograph.	H. Driving clock.
D. Exposing shutter.	I. Tripod for weight.
E. Cœlostat slow-motion handle.	J. 3-inch telescope and spectroscope.

Having obtained letters of introduction to some landowners in the district we intended to occupy, we went at once to the village of Zeralda, about 20 miles west from Algiers, and making this our head-quarters for a few days we explored the neighbouring country.

The people to whom my brother had letters received us with the greatest civility, and we desire to mention in particular M. Buloff,

administrator of the estate of the Comte de Perigord, and formerly Professor at Stonyhurst. This gentleman was much interested in our mission, and we are practically indebted to him for giving us a letter to a colonist, M. Alvado, upon whose farm near the sea coast we eventually found an excellent site for our camp.

It was evident at the outset that the wild hilly region near the village of Maelma would be more difficult of access than the country further west near the coast. Maelma itself we found to be poverty-stricken and unpromising. The mayor, whom we found in his mairie busy with the coming elections, was obliging enough to *visé* our document from the Préfecture; or rather he got his secretary to do so, being unable himself, apparently, to read or write. Having had our letter duly *viséd* we abandoned Maelma, and proceeded to the Mazafran River, near the coast, to conclude negotiations already entered into with Alvado.

These presented no difficulty, for M. Alvado was "un homme très brave," and offered us his whole territory, vineyards or cornfields, for our camping-ground. We were, however, limited in our choice to a line bearing West and $24\frac{1}{2}$ degrees North from Maelma, in order to secure the same duration of totality as had been computed for that place.

The position finally chosen was near to the mouth of the Mazafran River on the east side, and about 1 kilometre from the sea.

The position of the Mazafran bridge, about 400 metres distant, was ascertained from a recent survey to be

North latitude	36°	41′	35″
East longitude	2	48	30

The position of the camp, which my brother carefully determined by triangulation from the bridge, was as follows:—

North latitude	36°	41′	47″
East longitude	2	48	41

It was 17 metres above sea-level, and 6·5 kilometres from the station near Maelma, in a direction bearing West 25° North.

As the direction of the shadow track in this region was ascertained to be 24° 39′ North of West, we concluded that the above position would be safe for a duration of 30 seconds of totality.

Having settled all preliminaries we returned to Algiers to arrange for the transport of the instruments. This was effected without difficulty by means of the light railway recently constructed from Algiers to the Mazafran.

On May 9th we returned to Alvado's farm, and the next day the work of erection was begun.

Our hut, which was to serve as sleeping and living room as well as observatory, we had ready for occupation the same evening.

During the fortnight preceding the eclipse, our time was fully occupied in erecting and adjusting the three spectrographs, cœlostat, and other instruments, and in taking trial photographs for determining focus. We also made daily observations of the sun with a sextant and artificial horizon for determining time, and checking the rate of a chronometer which we had hired for use in our camp. Being far from any telegraph station in direct communication with Algiers, we were obliged to depend entirely on observation for our time on the day of the eclipse. Working with instruments of very second-rate quality, my brother usually succeeded in determining local time within one or two seconds of error, taking the mean of a day's set of observations (usually employing the method of double altitudes).

During the whole time we were in camp, we were ably assisted by our host, M. Alvado, who took a most intelligent interest in all our operations, and was ever ready and at hand to help us in any and every difficulty with which we were confronted. We take this opportunity of expressing our high appreciation of his services, and esteem for his character, and that of his wife, Madame Alvado. The latter attended most assiduously to all our personal wants, and in this way furthered most materially the objects of the expedition.

Observations made on the Day of the Eclipse.

Between 6 and 7 A.M. on May 28th I observed in the spectroscope the position angles and approximate heights of all the prominences then visible on the sun's limb. The results were then written out in accordance with a previously arranged code, and sent on to Zeralda to be telegraphed to Mr. A. C. D. Crommelin, at Algiers, for the use of intending observers of the coronal structure near to prominences.

The following table gives the position angles and heights observed:—

Position angle.	Solar latitude.	Approximate height Hα.
64°	+ 9°	50″
119	−46	15
217	−36	115/130
236	−17	25
305	+52	20

The rest of the morning was devoted to final adjustments and rehearsals; cleaning all lenses and prisms, and in taking more photographs for focus in the 2-inch spectrograph. Soon after noon all slides were filled ready for the eclipse; and lastly, the 9-inch mirror and the cœlostat mirror were both dusted and carefully polished with rouge to remove all trace of tarnish.

Fifteen minutes before mid-eclipse the large spectrograph was slightly readjusted for focus by observing with a lens the spectrum image of the diminishing crescent. This was effected without any difficulty or uncertainty.

I then attempted to focus the 2-inch spectrograph in the same way, using the Fraunhofer lines near G, which were then rapidly becoming sharply defined. As the last determination made photographically appeared to be correct, I set it again to the same position.

Five minutes before mid-eclipse my brother wound up the cœlostat clock, and three minutes later I gave the order "Stand by."

The light waned rapidly, and I began the exposures at $4^h\ 16^m\ 58^s$. At $4^h\ 17^m\ 30^s$ I found it difficult to see the seconds hand of the chronometer, and a few seconds later I opened for the 10-second exposure, giving at the same time the signal to expose the quartz spectrograph. The absence of any sound from the shutter warned us that the latter had failed to act.

At $4^h\ 18^m$ I could again see the chronometer face clearly. I continued the exposures according to the programme, finishing the last at $4^h\ 18^m\ 18^s$.

A minute or two later, after removing all the plate holders from their slides, I observed the large prominences on the south-west limb in the spectroscope attached to the 3-inch telescope. They appeared, of course, exceedingly brilliant in the line Hα. Unfortunately, I was unable to make a critical examination of the spectrum, for at this time a crowd of sight-seers inundated the entire camp, and further observation for the time being was impossible.

Later, I observed the time of last contact with the spectroscope. This took place at

5^h	21^m	34^s	per clock.
		+58	assumed error of clock.
5	22	32	G.M.T.

At this moment the moon's limb was seen as a black line projected on the chromosphere.

(4) *Results.*

Notwithstanding the fact that my station was outside the zone of total eclipse,* the photographs show that there was quite half a minute

* From the descriptions given us immediately after the eclipse by M. Alvado and others who undertook to determine accurately the duration of totality, it appeared certain that the photosphere never wholly disappeared, a small point of sunlight remaining visible at the moment of mid-eclipse. The edge of the moon's shadow was, moreover, clearly seen traversing the sea and the sand dunes a short distance north of our camp, which escaped the shadow by a few hundred metres only.

available for obtaining good images of the flash spectrum. No. 9 spectrum, for instance, is one of the finest of the series, and shows about as many bright lines as the mid-eclipse photograph, yet it was exposed 15 seconds before mid-eclipse. Several other photographs taken earlier than No. 9 also show a large number of flash spectrum lines.

I think this result demonstrates the very great advantage gained at stations near the limit of total eclipse for studying this spectrum.

In cleaning the lens of the quartz spectrograph shortly before the eclipse, I unfortunately jammed the exposing shutter in such a way that it would not work at the critical time, and no photograph was obtained with this instrument.

Sixteen photographs were obtained with the 2-inch spectrograph, and sixteen with the reflecting spectrograph. The following table gives the approximate times of exposure, and the plates used in each instrument:—

Exposure No.	Approximate times.		Plates used.	
	Beginning.	Duration.	Reflecting spectrograph.	2-inch spectrograph.
	h. m. s.	sec.		
1	4 16 58	$\frac{1}{2}$	Sandell Triple	Sandell Perfect.
2	17 5	1	" "	" "
3	10	2	Sandell Perfect	" "
4	14	2	" "	" "
5	18	2	Edwards's Ordinary Medium	" "
6	23	2	" "	Imperial Ordinary (Backed)
7	27	2	" "	" "
8	31	2	" "	" "
9	35	2	" "	" "
10	40	2	" "	" "
11	45	10	" "	" "
12	18 0	2	" "	Sandell Triple.
13	4	2	Sandell Perfect	" "
14	9	2	" "	" "
15	13	$\frac{1}{2}$	Sandell Triple	" "
16	17	$\frac{1}{2}$	" "	" "

The images obtained with the 2-inch spectrograph are not in good focus. They are very dense in the region near G, but correctly exposed in the ultra-violet. The spectra extend from λ 3350 to λ 5100. Apparently the maladjustment of focus has produced a linear distortion of the images; and at the edges of several of the spectra, where the direction of the distortion coincides with the direction of the bright

lines, the focus appears to be quite perfect through the whole length of the spectrum.

This suggests that the lens, which was a thin one, was under some strain in its cell, and it accounts for the difficulty experienced in finding the true focus.

In the mid-eclipse photograph (No. 11) the bright lines are fairly well defined at the extreme end of the spectrum, and they can be traced in this photograph to λ 3320. All the lines between λ 3340 and λ 3500 can be identified with those shown on the best plate obtained in 1898.

The following table gives the wave-lengths and identifications of these lines as determined for the spectrum obtained in India. In identifying the lines with the elements given in column 4, I received great assistance from Mr. L. E. Jewell, who also supplied me with a revised list of wave-length values for the solar lines given in column 5.

The intensities (column 2) are estimated as follows:—

Lines just visible but extremely faint ...... = 0
The strongest lines in the spectrum .... = 10

Wave-length (flash spectrum).	Intensity.	Character.	Element.	Wave-length, Rowland (solar spectrum).
3326±	2	Wave-lengths roughly estimated on photograph No. 11 of 1900.		
3330±	2			
3333±	1			
3335±	2			
3340·0	1½	First line on photograph No. 3 of 1898	Cr ? *Ti*	3340·490
3342·3	2		Ti	42·012
3347·0	0	(One measure only)........	Ti	46·882
3349·4	4	Long	Ti	49·558
3354·0	2	Faintly extended	Sc	53·875
3358·5	2		Cr	58·649
3361·4	3½	Long	Ti	61·327
3368·3	3	Long	Cr	68·193
3373·0	4	Long	Ti	72·948
3380·4	3	Short	Ti	80·424
3384·0	4	Long	Ti	83·892
3388·1	3	Long	Ti	87·988
3392·1	1½	(One measure only)........	Zr ?	92·109
3394·7	3	Long	Ti	94·716
3399·3	1	Short		
3403·45	3	Faintly extended	Cr	3403·404
3405·17	1	Short	Co ?	05·217
3407·32	1	Short	Fe ?	07·597
3408·97	3	Long	Cr	08·911
3410·24	1	Visible on south side only.		
3415·01	1	Visible on south side only ..	Ni	14·911
3421·42	3½	Equal pair; long..........	Cr	21·353
3422·94	3½		Cr	22·892

Wave-length (flash spectrum).	Intensity.	Character.	Element.	Wave-length, Rowland (solar spectrum).
3425 ·46	0	One measure only; very short.		
3426 ·97	0			
3428 ·73	0			
3430 ·61	1	Short....................	Zr ?	3430 ·671
3433 ·54	4	Long	*Cr*, Ni	33 ·453 33 ·715
3438 ·40	2	Short....................	Zr ?	38 ·376
3440 ·93	3	Faintly extended..........	Fe, Fe	40 ·762 41 ·155
3442 ·24	4	Long	..	42 ·112
3444 ·39	3	Faintly extended..........	Ti	44 ·467
3446 ·34	2	Ill-defined	Ni	46 ·406
3452 ·86	2		Ni	53 ·039
3456 ·55	2	Ill-defined; short	Ti	56 ·528
3458 ·58	1		Ni	58 ·601
3460 ·53	3	Long	Mn	60 ·460
3461 ·68	2	Faintly extended	Ti, Ni	61 ·633 61 ·801
3463 ·05	1	Interrupted; very short....	Co	62 ·950
3464 ·32	1	Visible on continuous spectrum only.	Sr ?	64 ·608
3465 ·87	2	Very faintly extended......	Co, Fe	65 ·900 66 ·015
3467 ·46	0			
3468 ·72	0	.. .. ..	Fe	68 ·821
3471 ·33	1	Equal pair, short, and interrupted		
3472 ·58	1		Ni	72 ·680
3474 ·28	3	Long	Mn	74 ·287
3475 ·67	2	Short....................	Fe	75 ·594
3477 ·26	3	Long	Ti	77 ·323
3479 ·48	1½	Ill-defined; short..........	Zr ?	79 ·531
3481 ·20	1½		Zr ?	81 ·302
3483 ·08	3	Long	Mn	83 ·047
3488 ·85	3		Mn	88 ·817
3491 ·16	3		Ti	91 ·195
3493 ·22	2	Ill-defined	*Ni*, Fe	93 ·114 93 ·618
3494 ·60	1	Short.		
3496 ·17	3	Long.		
3497 ·82	2	Short.		
3499 ·14	0	Interrupted.		
3500 ·45	1	Short.		
3502 ·30	0	(One measure only)	Co	3502 ·394
3505 ·06	3½	Long; equal pair..........	Ti	05 ·036
3510 ·96	3½		Ti	10 ·985

In column 4 the predominating element in a group is put in italics.

The sixteen images of the cusp and flash spectra obtained with the reflecting spectrograph are in good focus throughout.* Each spectrum

* The very strong chromosphere arcs, such as H and K, show a faint coma on the more refrangible side. This has since been traced to slight irregular refraction at the base of the 60° prism. The fault is, however, too slight to appreciably affect the definition of any but the strongest lines.

is 8 inches long, and extends from λ 350 to λ 510. The width corresponding to the sun's diameter is 0·68 inch.

The finer flash spectrum lines in many of the photographs are particularly well defined in the ultra-violet.

The first four photographs of the series are much over-exposed and fogged, and only the stronger chromosphere arcs are visible at the edge of the continuous spectrum. In the succeeding images, the sky illumination becoming much diminished, the bright lines show up clearly on a light background.

In No. 9 the flash spectrum is fully developed in a rift in the continuous spectrum. This rift extends from position angle 140° to 148°, and includes a region between 67° and 75° south latitude. The bright lines crossing the rift are beautifully defined throughout the spectrum, and in the ultra violet they can be traced nearly as far as the continuous spectrum. The Fraunhofer lines are well defined upon the continuous spectrum, where the latter has not been over-exposed, and the whole spectrum in the ultra-violet is a mixture of bright and dark lines.

Accurate determinations of wave-length will result from the measurement of this negative.

No. 11. This was exposed for 10 seconds at the greatest phase of the eclipse. The continuous spectrum is broken up into five narrow bands, and the flash spectrum lines form long arcs crossing the bands. Most of these arcs extend over nearly 80° of the limb, and cover the entire south polar region, from latitude $-75°$ on the east side to latitude $-28°$ on the west.

The bright lines on this negative are more strongly impressed than on any of the others, and they can be clearly traced up to the end of the continuous spectrum at λ 350. The dark lines of the Fraunhofer spectrum are still traceable on the narrow strips of continuous spectrum.

This negative will give good wave-length determinations for all the finer lines between λ 350 and λ 510.

Good images of the flash spectrum are also impressed on photographs Nos. 10, 12, and 13.

General Conclusions.

(1) In its main features the flash spectrum at the south pole of the sun is the same as in low latitudes.

(2) No essential change is shown after an interval of four years; the spectra photographed by Shackleton, in 1896, and those obtained in 1898 and 1900, all appear to be identical so far as it has been possible to compare them.

(3) The flash spectrum, therefore, is probably as constant a feature of the solar surface as is the Fraunhofer spectrum.

With regard to instruments, the reflecting prismatic camera has proved to be a most efficient form of spectrograph for eclipse work.

The uniform focus over the entire range of spectrum, and the facility with which the adjustment for focus can be effected, are advantages which those who have worked with prismatic cameras will appreciate.

Another important advantage in the use of the reflector is the proximity of the exposing shutter to the plate holder, both of which can easily be controlled by one person. There is no signalling between the man at the plates and the man at the shutter.

There is again the advantage that there is no selective absorption of ultra-violet rays which occurs in lenses, and if the mirror is freshly polished there is no selective reflection for any of the rays which can be photographed.

In concluding, I have to acknowledge my great indebtedness to my brother for his untiring devotion to the interests of the expedition throughout. In all the negotiations necessary on arrival in the country he took a leading part, and was successful in obtaining the goodwill of every person with whom we came in contact.

The fine series of photographs which we obtained bear witness to his skill in carrying out, to the letter, the somewhat troublesome arrangements which I had planned for erecting and adjusting the instruments.

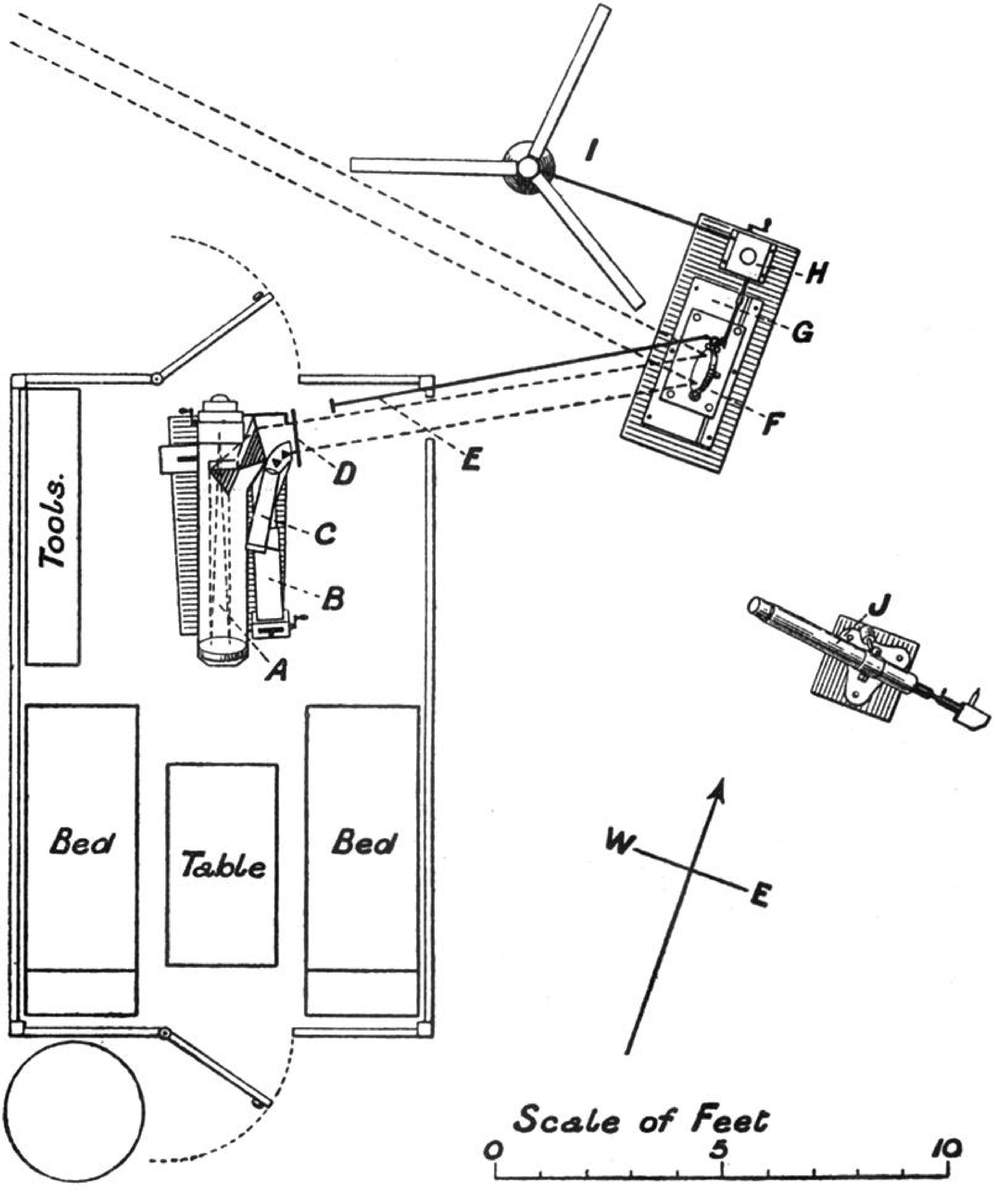
"Preliminary Note on Observations of the Total Solar Eclipse of 1900 May 28, made at Santa Pola (Casa del Pleito), Spain." By RALPH COPELAND, Ph.D., F.R.A.S., F.R.S.E.—Read at Joint Meeting of the Royal and Royal Astronomical Societies, June 28, 1900. MS. received October 1, 1900.

I had again the honour of being nominated one of the observers for the Joint Eclipse Committee, the station allotted to me being at Santa Pola, on the south-east coast of Spain.

On the 9th May I left Edinburgh, and sailed from Tilbury on the 11th in the Orient steamship "Oruba," accompanied by Mr. Thomas Heath, First Assistant at the Edinburgh Royal Observatory, who was going to Santa Pola to observe the eclipse on behalf of the Royal Society of Edinburgh.

My instrumental outfit had preceded me under the care of Mr. James McPherson, the experienced mechanician of our Edinburgh observatory. This outfit comprised the 40-foot horizontal telescope of 4-inch aperture previously used in India and Norway, together with a small Iceland spar and quartz prismatic camera, with an effective aperture of 1·8 inch.

PLAN OF OBSERVING STATION, MAZAFRAN CAMP.



A. Reflecting spectrograph.
B. 2-inch spectrograph.
C. Quartz spectrograph.
D. Exposing shutter.
E. Cœlostat slow-motion handle.
F. Cœlostat.
G. Planed steel plate with channel.
H. Driving clock.
I. Tripod for weight.
J. 3-inch telescope and spectroscope.